tangent screw (not drawn). The azimuth-circle I make of the same size, 9 feet diameter, read by six microscopes. There is no advantage gained in so large a circle, but rather the contrary. I hold that a circle of 30 inches, or 3 feet without spokes read by powerful microscopes, 6 feet in length, is capable of doing better work than one of 9 feet, subject to the same variations of temperature. I have drawn plans for four microscopes in altitude, two to each circle, but they may be replaced by six to each circle if required, and no objection is made to lengthening the platform.

It will be asked of what I propose to make the pivots,—I reply, of steel, shrunk on to the boiler-tube, and then turned down on dead centres. They will be 7 feet in diameter. The screws of the altitude circle appear to be turned the same way, but they work in opposite directions. My own are so placed.

The drawings are given to the scale of $\frac{1}{100}$ for the parabola and figs. 2 and 3, and $\frac{1}{16}$ for all the rest, in the originals; but in the lithographs are reduced one sixth again, so that figs. 1, 2, and 3 are in the proportion of $\frac{1}{600}$, and the others $\frac{1}{96}$.

It may be pointed out that by supposing a hollowed tube of 17 feet length, the mirrors of the first design can be supported throughout, resting on the back.

I have only to add, that I recommend that the webs of the micrometers be of parallel lines, of the same strength as the division which is seen between them; and that guide-lines should be engraved on the circles to indicate that the point viewed is the centre, and not any other part of the division. My circles at Churt are so divided.

On Mr. Carrington's Note of the Rate of a Clock going in a partial Vacuum. By Rev. T. R. Robinson, D.D.

I have read with much interest Mr. Carrington's account of the rate of his clock in a partial vacuum, given in the last Number of the *Monthly Notices;* for, although the barometric compensation which I applied to the Armagh transit-clock is completely successful, yet the adjustment of it requires too much time by calculation for that method to be generally adopted; while there is no great difficulty in establishing a clock in a rarefied medium of invariable density.

Mr. Carrington's chief impediment seems to have been the fracture of the plate-glass enclosing the front of his clock-case. This would not have occurred if he had constructed the case on the plan invented by Sir Edward Sabine, and modified by the late Mr. Francis Baily, in their researches on the reduction of a pendulum's rate to a vacuum (*Phil. Trans.* 1829 and 1832.) In their apparatus large flat surfaces of glass are avoided; and the pressure is sustained by convex ones, on the principle of the arch. Many years ago the late Sir James South made such an

apparatus, in which he tried several of his clocks for weeks together, in a vacuum as complete as an ordinary air-pump can produce. It consisted of a pear-shaped copper vessel about 30 inches diameter on a level with the bob of the pendulum; a strong ground brass plate was soldered to its top, on which the clock was fixed; and this was covered by a bell glass with a ground edge, like the receiver of an air-pump. A narrow slip of plate-glass below permitted the reading of the arc of vibration, but as this had a very small surface there was no danger of its fracture.*

I wish to direct the attention of astronomers to page 227 of Sir Edward Sabine's memoir, already referred to, where he describes the retardation in an atmosphere of dry hydrogen at the normal pressure. It is such as would occur in air at a pressure of 5·70 inches. A clock in such an atmosphere would require far less maintaining power, and would therefore work with less friction; while the oil applied to its moving parts would not be liable to chemical change from absorption of oxygen. There also would be much less danger of any alteration of the medium by leakage than in the case of a partial vacuum. Mr. Carrington's coefficient of barometric retardation is higher than what I found for the Armagh clock's mercurial pendulum = 0·37, or Mr. Baily's result for a detached one (*Phil. Trans.* 1832, p. 436) = 0·41.

The difference probably depends on the arc of vibration. This varied but little during my observations, and was allowed for in Mr. Baily's.

It may interest some readers of the *Monthly Notices* to know that the first application of a vacuum to horology was made about sixty years ago by Manton, the celebrated gunsmith, who submitted to the Admiralty a chronometer enclosed in an exhausted receiver, and wound through a stuffing-box. It was tried during a voyage of two years by the late Admiral Beaufort, who reported very favourably of its performance: but the Admiralty took no further action in the matter, and the affair seems to have been forgotten.

Observatory, Armagh,
December 20, 1872.

On a Compensation for the Barometric Errors of Clocks.
By E. B. Denison, LL.D., Q.C.

Mr. Carrington's paper in the November *Monthly Notices*, on the retardation of a pendulum by increased density of air, suggests the expediency of providing a compensation for it, which is so easy that I wonder it has not been done before. It seems indeed from Dr. Robinson's paper just now read, that it has been done in some way; but as he speaks of the difficulty of

* It is to be regretted that these experiments have not been published; they form part of an extensive investigation into the various circumstances which nfluence the going of a clock, which was conducted with great care.